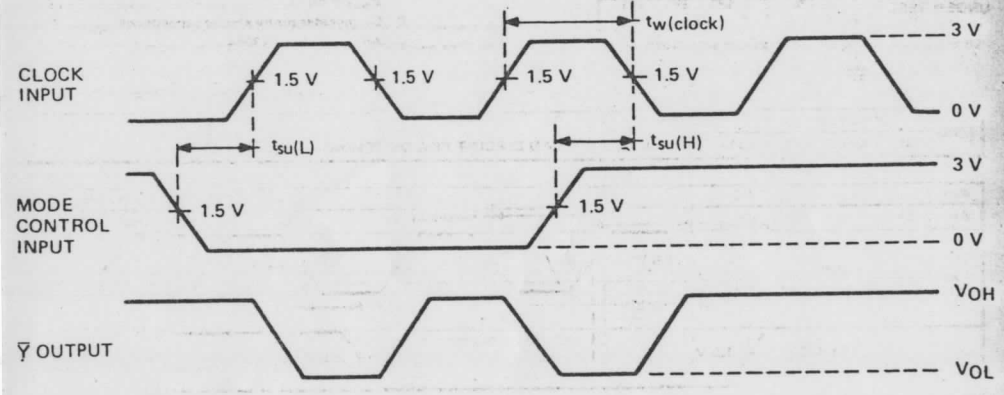
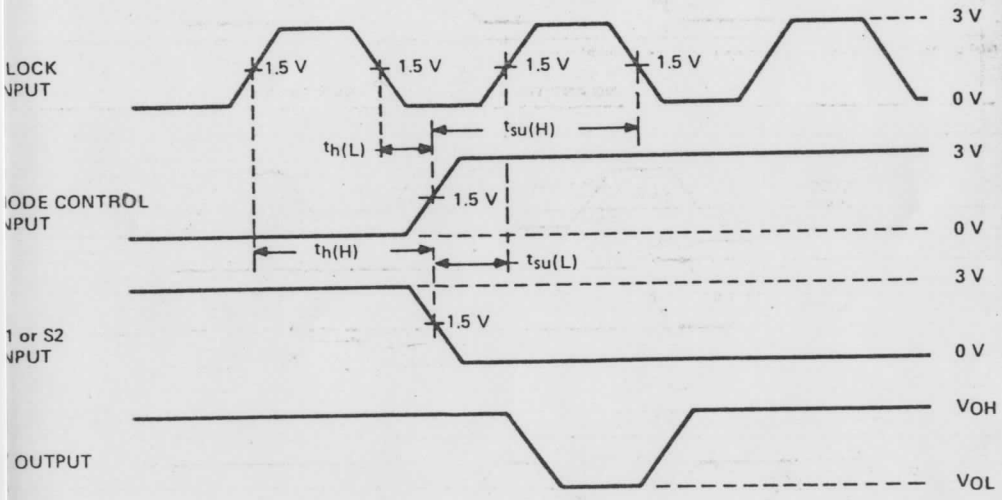
PARAMETER MEASUREMENT INFORMATION



NOTE: At least one of the S inputs is low.

FIGURE 4—INITIATING AND TERMINATING PULSE TRAIN WITH MODE CONTROL INPUT



OTE: Input R is low and the unused S input is high.

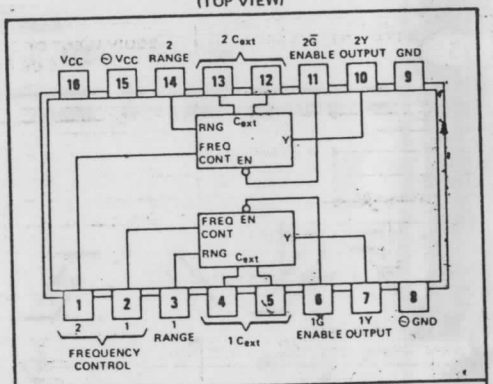
FIGURE 5—ENABLING SINGLE PULSE

DUAL VOLTAGE-CONTROLLED OSCILLATORS

BULLETIN NO. DL-S 7612025, MARCH 1974—REVISED OCTOBER 1976

- Two Independent VCO's in a 16-Pin Package
- Output Frequency Set by Single External Component:
  - Crystal for High-Stability Fixed-Frequency Operation
  - Capacitor for Fixed- or Variable-Frequency Operation
- Separate Supply Voltage Pins for Isolation of Frequency Control Inputs and Oscillators from Output Circuitry
- Highly Stable Operation over Specified Temperature and/or Supply Voltage Ranges

SN54LS124, SN54S124 . . . J OR W PACKAGE
SN74LS124, SN74S124 . . . J OR N PACKAGE
(TOP VIEW)



logic: While the enable input is low, the output is enabled. While the enable input is high, the output is high.

TYPE	GUARANTEED FREQUENCY SPECTRUM	TYPICAL f_{max}	TYPICAL POWER DISSIPATION
'LS124	1 Hz to 20 MHz	30 MHz	150 mW
'S124	1 Hz to 60 MHz	85 MHz	525 mW

description

The 'LS124 and 'S124 feature two independent voltage-controlled oscillators (VCO) in a single monolithic chip. The output frequency of each VCO is established by a single external component, either a capacitor or a crystal, in combination with two voltage-sensitive inputs, one for frequency range and one for frequency control. These inputs can be used to vary the output frequency as shown under typical characteristics for the 'S124. The concept also applies for the 'LS124. These highly stable oscillators can be set to operate at any frequency typically between 0.12 Hz and 30 MHz ('LS124) or 0.12 hertz and 85 megahertz ('S124). Under the conditions used in Figure 3, the output frequency can be approximated as follows:

$$f_o = \frac{1 \times 10^{-4}}{C_{ext}} \text{ for 'LS124,} \quad f_o = \frac{5 \times 10^{-4}}{C_{ext}} \text{ for 'S124}$$

where: f_o = output frequency in hertz

C_{ext} = external capacitance in farads.

These devices can operate from a single 5-volt supply. However, one set of supply-voltage and ground pins (V_{CC} and GND) is provided for the enable, synchronization-gating, and output sections, and a separate set ($\ominus V_{CC}$ and $\ominus$ GND) is provided for the oscillator and associated frequency-control circuits so that effective isolation can be accomplished in the system.

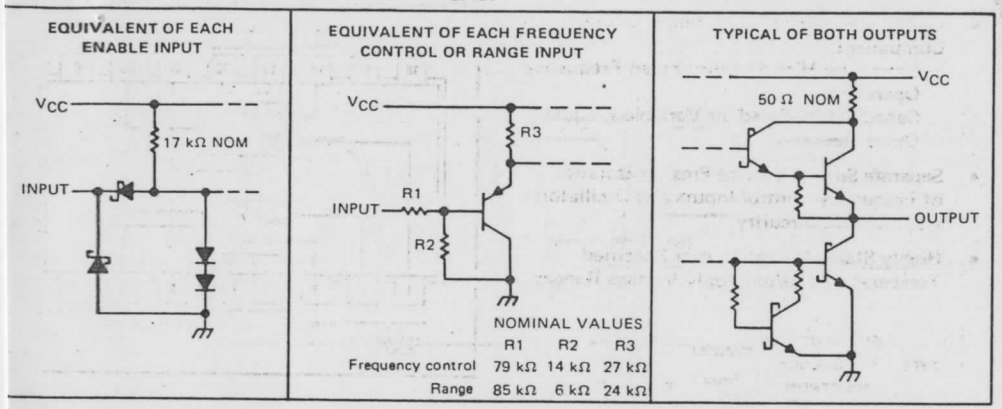
The enable input of these devices starts or stops the output pulses when it is low or high, respectively. The internal oscillator of the 'LS124 runs continuously even while the output is disabled, whereas the internal oscillator of the 'S124 is itself started and stopped by the enable input. The enable input is one standard load in each series. The enable input and the buffered output operate at standard Schottky-clamped TTL levels.

The pulse synchronization-gating section ensures that the first output pulse is neither clipped nor extended. Duty cycle of the square-wave output is fixed at approximately 50 percent. Simultaneous operation of both VCO's in the same package is not recommended.

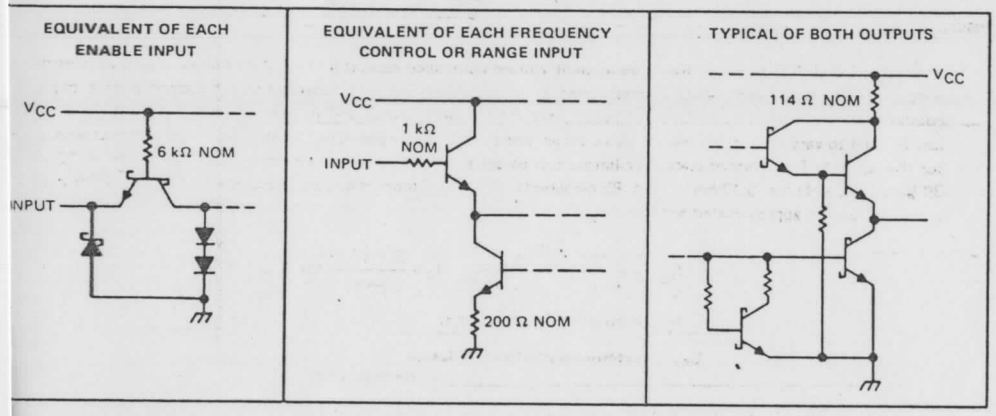
The SN54LS124 and SN54S124 are characterized for operation over the full military temperature range of −55°C to 125°C; the SN74LS124 and SN74S124 are characterized for operation from 0°C to 70°C.

schematics of inputs and outputs

'LS124



'S124



absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

Supply voltage, V_{CC} (see Notes 1 and 2) . . . . . 7 V
Input voltage: 'LS124 Enable input . . . . . 7 V
'LS124 Frequency control or range input . . . . . V_{CC}
'S124 . . . . . 5.5 V
Operating free-air temperature range: SN54LS124, SN54S124 . . . . . −55°C to 125°C
SN74LS124, SN74S124 . . . . . 0°C to 70°C
Storage temperature range . . . . . −65°C to 150°C

NOTES: 1. Voltage values are with respect to the appropriate ground terminal.
2. Throughout this data sheet, the symbol V_{CC} is used for the voltage applied to both the V_{CC} and ⊖V_{CC} terminals, unless otherwise noted.

recommended operating conditions

	SN54LS124			SN74LS124			UNIT
	MIN	NOM	MAX	MIN	NOM	MAX	
Supply voltage, V_{CC}	4.5	5	5.5	4.75	5	5.25	V
Input voltage at frequency control or range input, $V_{I(freq)}$ or $V_{I(rng)}$	0		5	0		5	V
High-level output current, I_{OH}			−1.2			−1.2	mA
Low-level output current, I_{OL}			12			24	mA
Output frequency (enabled), f_o	1			1			Hz
			20			20	MHz
Operating free-air temperature, T_A	−55		125	0		70	°C

electrical characteristics over recommended operating free-air temperature range (unless otherwise noted)

PARAMETER			TEST CONDITIONS†		SN54LS124			SN74LS124			UNIT
					MIN	TYP‡	MAX	MIN	TYP‡	MAX	
V_{IH}	High-level input voltage at enable				2			2			V
V_{IL}	Low-level input voltage at enable						0.7			0.8	V
V_{IK}	Input clamp voltage at enable		V_{CC} = MIN, I_I = −18 mA				−1.5			−1.5	V
V_{OH}	High-level output voltage		V_{CC} = MIN, V_{IH} = 2 V, I_{OH} = −1.2 mA		2.5	3.4		2.7	3.4		V
V_{OL}	Low-level output voltage		V_{CC} = MIN, ⊖V_{CC} open, V_{IL} = V_{IL}max	I_{OL} = 12 mA		0.25	0.4		0.25	0.4	V
				I_{OL} = 24 mA					0.35	0.5	
I_I	Input current	Freq control or range	V_{CC} = MAX	V_I = 5 V		50	250		50	250	μA
				V_I = 1 V		10	50		10	50	
I_I	Input current at maximum input voltage	Enable	V_{CC} = MAX, V_I = 7 V				0.1			0.1	mA
I_{IH}	High-level input current	Enable	V_{CC} = MAX, V_I = 2.7 V				20			20	μA
I_{IL}	Low-level input current	Enable	V_{CC} = MAX, V_I = 0.4 V				−0.4			−0.4	mA
I_{OS}	Short-circuit output current§		V_{CC} = MAX		−40		−225	−40		−225	mA
I_{CC}	Supply current, total into pins 15 and 16		V_{CC} = MAX, See Note 2			30	50		30	50	mA

†For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.
‡All typical values are at V_{CC} = 5 V, T_A = 25°C.
§Not more than one output should be shorted at a time and duration of the short-circuit should not exceed one second.
NOTE 2: I_{CC} is measured with the outputs disabled and open.

switching characteristics, V_{CC} = 5 V (unless otherwise noted), R_L = 667 Ω, C_L = 45 pF, T_A = 25°C

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
f_o	Output frequency (capacitor controlled)	C_{ext} = 2 pF	$V_{I(freq)}$ = 4 V, $V_{I(rng)}$ = 1 V	20	30		MHz
			$V_{I(freq)}$ = 1 V, $V_{I(rng)}$ = 5 V	11	20		
f_o	Output frequency (crystal controlled)	⊖V_{CC} = 3 V, $V_{I(freq)}$ = $V_{I(rng)}$ = 0 V		10	20		MHz
	Output duty cycle	C_{ext} = 8.3 pF to 500 μF			50%		
t_{PHL}	Propagation delay time, high-to-low-level output from enable	f_o > 1 Hz			30+*		ns

*The delay will typically be 30 ns plus up to one period of one cycle (i.e. 30 ns to 30 ns + $\frac{1 \times 10^9}{f_{o(Hz)}}$ ns) depending upon the timing of the enable pulse with respect to the signal generated by the internal oscillator.

ommended operating conditions

	SN54S124			SN74S124			UNIT
	MIN	NOM	MAX	MIN	NOM	MAX	
Supply voltage, V_{CC} (see Note 1)	4.5	5	5.5	4.75	5	5.25	V
Input voltage at frequency control or range input, $V_{I(freq)}$ or $V_{I(rng)}$	1		5	1		5	V
High-level output current, I_{OH}			−1			−1	mA
Low-level output current, I_{OL}			20			20	mA
Output frequency (enabled), f_o	1			1			Hz
			60			60	MHz
Operating free-air temperature, T_A	−55		125	0		70	°C

E 1: Throughout this data sheet, the symbol V_{CC} is used for the voltage applied to both pins 15 and 16.

ctrical characteristics over recommended operating free-air temperature range (unless otherwise noted)

PARAMETER			TEST CONDITIONS†		MIN	TYP‡	MAX	UNIT
V_{IH}	High-level input voltage at enable				2			V
V_{IL}	Low-level input voltage at enable						0.8	V
V_{IK}	Input clamp voltage at enable		V_{CC} = MIN, I_I = −18 mA				−1.2	V
V_{OH}	High-level output voltage		V_{CC} = MIN, V_{IH} = 2 V, I_{OH} = −1 mA	SN54S'	2.5	3.4		V
				SN74S'	2.7	3.4		
V_{OL}	Low-level output voltage		V_{CC} = MIN, V_{IL} = 0.8 V, I_{OL} = 20 mA				0.5	V
I_I	Input current	Freq control or range	V_{CC} = MAX	V_I = 5 V		10	50	μA
				V_I = 1 V		1	15	
I_I	Input current at maximum input voltage	Enable	V_{CC} = MAX, V_I = 5.5 V				1	mA
I_{IH}	High-level input current	Enable	V_{CC} = MAX, V_I = 2.7 V				50	μA
I_{IL}	Low-level input current	Enable	V_{CC} = MAX, V_I = 0.5 V				−2	mA
I_{OS}	Short-circuit output current§		V_{CC} = MAX		−40		−100	mA
I_{CC}	Supply current, total into pins 15 and 16		V_{CC} = MAX, See Note 2			105	150	mA
			V_{CC} = MAX, T_A = 125°C, See Note 2	W package only			110	

conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.
typical values are at V_{CC} = 5 V, T_A = 25°C.
more than one output should be shorted at a time and duration of the short-circuit should not exceed one second.
E 2: I_{CC} is measured with the outputs disabled and open.

ching characteristics, V_{CC} = 5 V, R_L = 280 Ω, C_L = 15 pF, T_A = 25°C

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
f_o	Output frequency	C_{ext} = 2 pF	$V_{I(freq)}$ = 4 V, $V_{I(rng)}$ = 1 V	60	85		MHz
			$V_{I(freq)}$ = 1 V, $V_{I(rng)}$ = 5 V	25	40		
	Output duty cycle	C_{ext} = 8.3 pF to 500 μF			50%		
t_{PHL}	Propagation delay time, high-to-low-level output from enable	f_o = 1 Hz to 20 MHz			$\frac{1.4}{f_{o(Hz)}}$		s
		f_o > 20 MHz			70		ns

TYPICAL APPLICATION DATA

free-running oscillator

Free-running oscillators can be implemented for most systems by setting the output frequency of the VCO with either a capacitor or a crystal. If excitation is provided with a capacitor the frequency control and/or range inputs can be used to vary the output frequency.

When the 'S124 is excited with a crystal, low-frequency response ($\leq$ 1 MHz) can be improved if a relatively small capacitor (5 to 15 pF) is paralleled with the crystal. When operated at the fundamental frequency of a crystal, the frequency control input should be high ($\approx$ 5 V) and the range input should be low (grounded) for maximum stability over temperature and supply voltage variations.

When the 'LS124 is excited with a crystal, a small capacitor (2 to 10 pF) should be placed in series with the crystal and the $\ominus V_{CC}$ supply should be lowered to approximately 3 V. A series-resonant, fundamental-mode crystal with series resistance less than 200 ohms should be used. The frequency control and range inputs should be grounded. The maximum recommended frequency for crystal-excited operation is 10 MHz.

phase-locked loops

A basic crystal-controlled phase-locked loop is illustrated in Figure 1. This application can be used for implementation of:

a. A highly stable fixed-frequency clock generator.
b. A highly stable fixed- or variable-frequency synthesizer.
c. A highly efficient "slave-clock" system for synchronizing off-card, remote, or data-interfacing clock systems

With fixed division rates for both M and N, the output frequency (f_o) will be stable at $f_o = \frac{N}{M} f_1$. Obviously, either M or N, or both, could be programmable counters in which case the output frequency (f_o) will be a variable frequency dependent on the instantaneous value of $\frac{N}{M} f_1$.

The crystal-controlled VCO can be operated up to 60 MHz with an accuracy that is dependent on the crystal. At the higher frequencies, response of the phase comparator can become a limiting factor and one of the following approaches may be necessary to extend the operating frequency range.

a. Frequencies $\frac{f_1}{M}$ and $\frac{f}{N}$ can be divided equally by the same constant (K) also shown in Figure 1. The constant can be any value greater than unity (K > 1), and should be selected to yield frequency ranges that can be handled adequately by the phase-comparator and filter. The output frequency (f_o) retains the same relationship as previously explained because now:

$$f_o = \frac{KN}{KM} f_1 = \frac{N}{M} f_1$$

b. In another method, the comparison of $\frac{f_1}{M}$ and $\frac{f}{N}$ can be performed with either an SN54LS85/SN74LS85 or SN54S85/SN74S85. The resultant A > B and A < B outputs from the 'LS85 or 'S85 permit the detector to be simplified to a charge-pump circuit. See Figure 2.

TYPICAL APPLICATION DATA

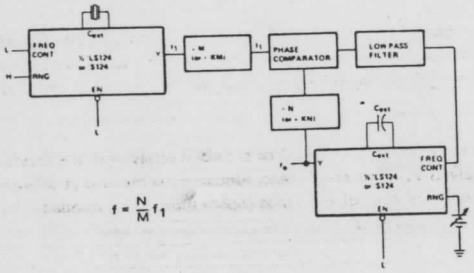


FIGURE 1–PHASE-LOCKED LOOP

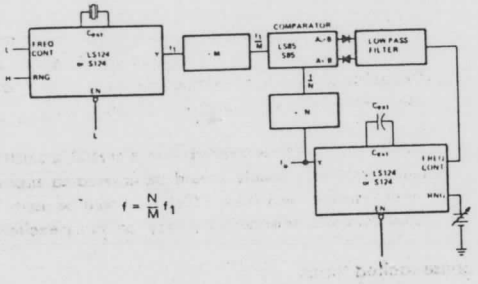


FIGURE 2–HIGH-FREQUENCY PHASE-LOCKED LOOP

TYPICAL CHARACTERISTICS ('S124 only)

BASE OUTPUT FREQUENCY
vs
EXTERNAL CAPACITANCE

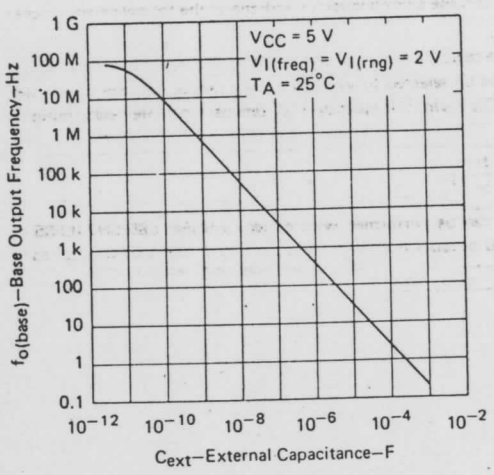


FIGURE 3

NORMALIZED OUTPUT FREQUENCY
vs
INPUT VOLTAGE

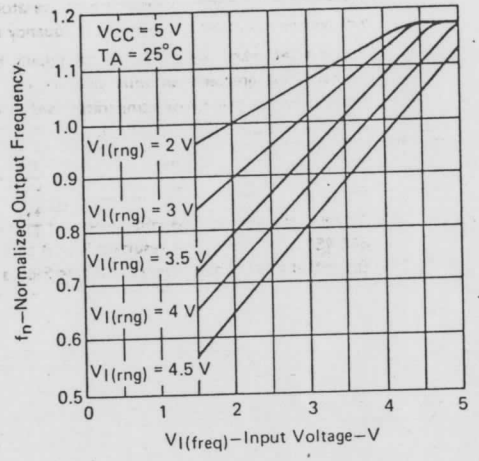


FIGURE 4

NOTE: $f_o = f_n \times f_{o(base)}$.

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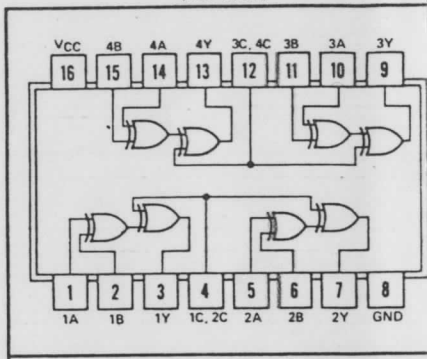
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

- Fully Compatible with Most TTL and TTL MSI Circuits
- Fully Schottky Clamping Reduces Delay Times . . . 8 ns Typical
- Can Operate as Exclusive-OR Gate (C Input Low) or as Exclusive-NOR Gate (C Input High)

SN54S135 . . . J OR W PACKAGE
SN74S135 . . . J OR N PACKAGE
(TOP VIEW)



FUNCTION TABLE

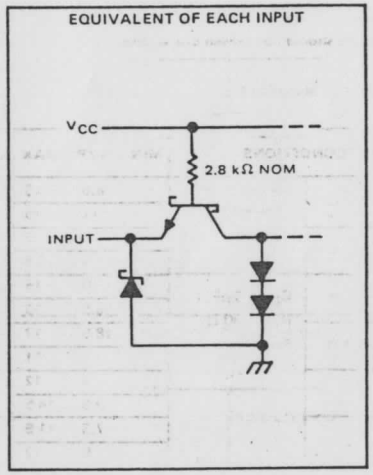
INPUTS			OUTPUT
A	B	C	Y
L	L	L	L
L	H	L	H
H	L	L	H
H	H	L	L
L	L	H	H
L	H	H	L
H	L	H	L
H	H	H	H

H = high level, L = low level

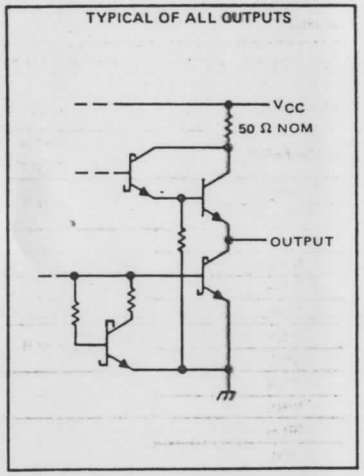
positive logic: $Y = (A \oplus B) \oplus C = A\bar{B}\bar{C} + \bar{A}\bar{B}C + \bar{A}B\bar{C} + ABC$

schematics of inputs and outputs

EQUIVALENT OF EACH INPUT



TYPICAL OF ALL OUTPUTS



absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

Supply voltage, V_{CC} (see Note 1) 5
Input voltage 5
Operating free-air temperature range: SN54S135 . . . . . −55°C to 12
SN74S135 . . . . . 0°C to 7
Storage temperature range . . . . . −65°C to 15

NOTE 1: Voltage values are with respect to network ground terminal.

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